

CLAIMS

1. A fuel cell system, comprising:

a fuel cell (1) which generates power by supplying an oxidizing agent and a hydrogen-containing gas to an electrolyte membrane (1m),

a water supply device (9, 12) which supplies water to the fuel cell (1),
and

a controller (20) functioning to:

estimate a restart time when the fuel cell (1) is restarted,

estimate a shift of an outside air temperature,

compute a first energy amount required when the system is protected by a first protection mode which prevents freezing of water in the system by heating water supplied to the fuel cell (1) when the fuel cell (1) has stopped, and a second energy amount required when the system is protected by a second protection mode which prevents freezing of water in the system by discharging water from the fuel cell (1) when the fuel cell (1) has stopped, respectively based on the estimated restart time and outside air temperature shift,

select the first protection mode when the first energy amount is less than the second energy amount, and select the second protection mode when the first energy amount is larger than the second energy amount as a protection mode used when the fuel cell (1) has stopped, and

protect the system with the selected protection mode.

2. The fuel cell system as defined in Claim 1, further comprising:

a sensor (51) which detects day and time, and wherein
the controller (20) further functions to estimate the shift of outside air
temperature based on the detected day and time.

3. The fuel cell system as defined in Claim 1, further comprising:

a sensor (32) which detects a position of the system, and wherein
the controller (20) further functions to estimate the shift of outside air
temperature based on the detected system position.

4. The fuel cell system as defined in Claim 1, further comprising:

a sensor (34) which detects an illumination surrounding the system,
and wherein:
the controller (20) further functions to estimate the shift of outside air
temperature based on the detected illumination.

5. The fuel cell system as defined in Claim 1, further comprising:

a device (52) into which climatic information is input, and wherein:
the controller (20) further functions to estimate the shift of outside air
temperature based on the input climatic information.

6. The fuel cell system as defined in any of Claims 1 to 5, further
comprising:

a sensor (33) which detects the outside air temperature, and wherein:
the controller (20) further functions to correct the estimated outside
air temperature shift based on the difference between the outside air

temperature obtained from the estimated outside air temperature shift and the detected outside air temperature.

7. The fuel cell system as defined in any of Claims 1 to 5, wherein:

the controller (20) further functions to apply a difference between an actual restart time when the fuel cell (1) actually restarts and the estimated restart time, to the estimation of restart time on the next occasion.

8. The fuel cell system as defined in any of Claims 1 to 5, further comprising:

a device (37) into which a driver inputs the restart time, and wherein:

the controller (20) further functions, when there is an input restart time, to estimate that the fuel cell (1) restarts at the input restart time.

9. The fuel cell system as defined in any of Claims 1 to 5, wherein:

the controller (20) further functions to correct the estimated restart time when the fuel cell (1) is not restarted although a predetermined time after the estimated restart time has elapsed, and perform the protection mode selection again based on the corrected restart time.

10. The fuel cell system as defined in Claim 9, wherein:

the controller (20) further functions to correct the estimated restart time based on a difference between the estimated restart time and an actual restart time.

11. The fuel cell system as defined in any of Claims 1 to 5, further comprising:

a sensor (31, 36) which detects a remaining energy amount in the system, and wherein:

the controller (20) further functions to stop protection of the fuel cell (1) in the first protection mode when the detected remaining energy amount in the system is less than a predetermined value.

12. The fuel cell system as defined in any of Claims 1 to 5, further comprising:

a sensor (35) which detects an oxygen concentration outside the system, and wherein:

the controller (20) further functions to stop protection in the first protection mode when the detected oxygen concentration outside the system is lower than a predetermined value.

13. The fuel cell system as defined in any of Claims 1 to 5, further comprising:

a device (41, 42) which issues an alarm when the remaining energy amount in the system is less than a predetermined value.

14. The fuel cell system as defined in any of Claims 1 to 5, wherein:

the controller (20) further functions to start thawing ice which has frozen outside the fuel cell (1) from a predetermined time prior to the

estimated restart time when the system is protected in the second protection mode.

15. The fuel cell system as defined in any of Claims 1 to 5, further comprising:

a switch (53) which starts the fuel cell (1), and wherein:

the controller (20) further functions to stop protecting the system and start the fuel cell (1) when the switch (53) is operated when the system is protected by the first or second protection mode.

16. A method of protecting a fuel cell system having a fuel cell (1) which generates power by supplying an oxidizing agent and a hydrogen-containing gas to an electrolyte membrane (1m), and a water supply device (9, 12) which supplies water to the fuel cell (1), the method comprising:

estimating a restart time when the fuel cell (1) is restarted,

estimating a shift of an outside air temperature,

computing a first energy amount required when the system is protected by a first protection mode which prevents freezing of water in the system by heating water supplied to the fuel cell (1) when the fuel cell (1) has stopped, and a second energy amount required when the system is protected by a second protection mode which prevents freezing of water in the system by discharging water from the fuel cell (1) when the fuel cell (1) has stopped, respectively based on the estimated restart time and outside air temperature shift,

selecting the first protection mode when the first energy amount is less than the second energy amount, and selecting the second protection mode when the first energy amount is larger than the second energy amount as a protection mode used when the fuel cell (1) has stopped, and protecting the system with the selected protection mode.

17. A fuel cell system, comprising:

- a fuel cell (1) which generates power by supplying an oxidizing agent and a hydrogen-containing gas to an electrolyte membrane (1m),

- a water supply device (9, 12) which supplies water to the fuel cell (1),

- means for estimating a restart time when the fuel cell (1) is restarted,

- means for estimating a shift of an outside air temperature,

- means for computing a first energy amount required when the system is protected by a first protection mode which prevents freezing of water in the system by heating water supplied to the fuel cell (1) when the fuel cell (1) has stopped, and a second energy amount required when the system is protected by a second protection mode which prevents freezing of water in the system by discharging water from the fuel cell (1) when the fuel cell (1) has stopped, respectively based on the estimated restart time and outside air temperature shift,

- means for selecting the first protection mode when the first energy amount is less than the second energy amount, and select the second protection mode when the first energy amount is larger than the second energy amount as a protection mode used when the fuel cell (1) has stopped, and

- 33 -

means for protecting the system with the selected protection mode.